Citation:

Engberink MF, Hendriksen MA, Schouten EG, van Rooij FJ, Hofman A, Witteman JC, Geleijnse JM. Inverse association between dairy intake and hypertension: the Rotterdam Study. *Am J Clin Nutr*. 2009 Jun;89(6):1877-83. Epub 2009 Apr 15.

PubMed ID: 19369377

Study Design:

Prospective Cohort Study

Class:

B - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

POSITIVE: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

The purpose was to assess whether hypertension is associated with dairy consumption.

Inclusion Criteria:

- Subjects who were ≥ age 55 in the Rotterdam suburb

Exclusion Criteria:

- Subjects who had hypertension at baseline
- Subjects with no baseline information on hypertension
- Subjects who had no information on hypertension status at both follow-up visits (lost to follow-up or had no blood pressure measurements at follow-up sessions)

Description of Study Protocol:

Recruitment - This study was part of the Rotterdam Study. All residents of a Rotterdam suburb who met the age requirement were invited to participate.

Design - Population-based prospective cohort study

Blinding used (if applicable): not applicable

Intervention (if applicable): not applicable

Statistical Analysis

- Intake of total dairy and specific dairy were adjusted for total energy intake using the residual method and divided into quartiles.
- Subjects were compared at baseline across quartiles to identify potential confounders.
- Cox proportional hazard modeling was used to calculate hazard ratios (HRs with 95% CIs) for hypertension in quartiles of energy-adjusted dairy use with the lowest quartile as the reference.

- Person-time of follow-up from baseline to study completion was used for nonhypertensive subjects.
- For those who became hypertensive, the researchers attributed 1 year of follow-up if hypertension was noted during the 2-year exam visit and 4 years of follow-up if hypertension was found during the 6-year exam visit.
- Hazard ratios (HRs) were first calculated for association between dairy intake and 2-year incidence of hypertension.
- The basic model covered age (continuous) and gender.
- Multivariate analysis with adjustment was used for some characteristics. Additional adjustment was made for intake of certain food items.
- All measures were repeated for the association between dairy use and 6-year rate of hypertension.
- SAS software was used for data analysis. *P* values are 2-sided.
- Linear trends across dairy groups were assessed by using median values within quartiles as a linear covariate.
- Predefined stratified analyses were used based on results from previous studies.
- Subgroup analyses were done in strata of gender and overweight.

Data Collection Summary:

Timing of Measurements

- Baseline and follow-up (2-year and 6-year) measurements were obtained.
- Baseline was 1990 - 1993
- Blood pressure reexamined in 1993 - 1995 and 1997 - 1999

Dependent Variables

- Blood pressure
- Hypertension

Independent Variables

- Five categories of types of dairy foods were created (milk and milk products, cheese, low-fat dairy, high-fat dairy, and fermented dairy).
- Participants completed a checklist at home that queried about foods and drinks they had consumed at least twice per month during the preceding year
- Underwent standardized interview with the dietitian regarding the checklist, using a 170-item semiquantitative food frequency questionnaire

Control Variables

- Energy
- Age
- Sex
- BMI
- Smoking
- Educational level
- Dietary factors
- Intakes of alcohol and total energy

Description of Actual Data Sample:

Initial N: 7983 older adults

Attrition (final N): 2245

Age: ≥ 55

Ethnicity: Assumed Caucasian

Other relevant demographics:

Anthropometrics

Location: Division of Human Nutrition, Wageningen University and Research Centre, Netherlands and the Department of Epidemiology and Biostatistics, Erasmus Medical Center, Rotterdam, Netherlands

Summary of Results:

Key Findings

- Risk of hypertension after 2 years of follow-up (664 incident cases) was inversely associated with dairy product intake.
- After adjustment for confounders, hazard ratios were 1.00, 0.82 (95% confidence interval: 0.67 - 1.02), 0.67 (0.54 - 0.84), and 0.76 (0.61 - 0.95) in consecutive quartiles of total dairy product intake (P for trend = 0.008).
- Corresponding hazard ratios for low-fat dairy products were 1.00, 0.75 (0.60 - 0.92), 0.77 (0.63 - 0.96) and 0.69 (0.56 - 0.86), in consecutive quartiles (P for trend = 0.003).
- Analysis of specific types of dairy products showed an inverse association with milk and milk products (P for trend = 0.07) and no association with high fat dairy or cheese (P > 0.6).
- After 6 years of follow-up (984 incident cases), the associations with hypertension were attenuated to risk reductions of ~20% for both total and low-fat dairy products between the first and last quartiles of intake (P for trend = 0.07 and 0.09, respectively).

Other Findings

Baseline characteristics

- Higher dairy intake was associated with lower intake of meat, bread, and coffee.
- The lowest category of dairy intake included more males and current smokers.
- The lowest category of dairy intake was linked with higher intake of total calories, total fat, saturated fat, and alcohol.

Dairy consumption

- Median energy-adjusted dairy intake was 396 grams/day.
- The largest intake of total dairy was from low-fat milk, buttermilk, high-fat milk, low-fat yogurt, and Gouda cheese.
- There was high correlation with total dairy intake and low-fat dairy intake (Spearman correlation: $r = 0.77$, $p < 0.0001$).

Dairy intake and 2-year incidence of hypertension

- 664 cases of hypertension were identified at this stage of follow-up.
- 7% decrease in hypertension was noted with each dairy serving-per-day (150 ml).
- Intake of milk and milk products were the only groups with inverse association to incident hypertension. Fermented dairy foods also had inverse association at 2 years but not at 6 years.
- There was no significant variance for the association between dairy intake and hypertension by gender (p for interaction = 0.41).
- Hazard ratios for low-fat dairy intake in higher quartiles compared to lower quartiles were 0.61 (0.43, 0.88) for men and 0.74 (0.55, 0.98) for women (p for trend = 0.03 and 0.04, respectively).

Dairy intake and 6-year incidence of hypertension

- 984 cases of hypertension were identified at this stage of follow-up.
- Fermented dairy foods had no association with hypertension risk.
- Hazard ratios for low-fat dairy intake from lowest to highest quartiles were 1.00, 0.82 (0.64, 1.07), 0.79 (0.60, 1.05), 0.75 (0.56, 0.99) for men (p for trend = 0.04) and 1.00, 0.90 (0.69, 1.17), 0.82 (0.64, 1.06), 0.90 (0.70, 1.16) for women (p for trend = 0.45, p for interaction = 0.46).

Author Conclusion:

Low-fat dairy intake may be related to prevention of hypertension as people age.

Reviewer Comments:

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions

1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	Yes
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	Yes

Validity Questions

1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	Yes
2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	Yes
3.	**Were study groups comparable?**	Yes
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	Yes
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	Yes
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes

3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	Yes
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	Yes
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	Yes
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	Yes
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	**Was blinding used to prevent introduction of bias?**	Yes
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	Yes
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	Yes
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	Yes
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	N/A

6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	N/A
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	Yes
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes
7.7.	Were the measurements conducted consistently across groups?	Yes
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	N/A
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
8.6.	Was clinical significance as well as statistical significance reported?	Yes

8.7.	If negative findings, was a power calculation reported to address type 2 error?	N/A
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**	Yes
9.1.	Is there a discussion of findings?	Yes
9.2.	Are biases and study limitations identified and discussed?	Yes
10.	**Is bias due to study's funding or sponsorship unlikely?**	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	Yes